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THE INSTITUTE OF TECHNICAL ACOUSTICS AT THE TECHNICAL UNIVERSITY OF BERLIN – A FOUNDATION AT THE RIGHT TIME AND PLACE

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ABSTRACT

Starting from and continuing multiple previous efforts to investigate the physics of vibrations and waves in Mechanics and Acoustics at the Institute of Mechanics of Technical University Berlin (TUB) and the Heinrich-Hertz-Institute (HHI) in Berlin, in 1954 the Institute of Technical Acoustics at TU Berlin was founded. In close agreement with the profile of its highly regarded founding director, Lothar Cremer, the Institute aimed at exploring, developing and providing engineerable approaches, methods and technologies to control sound and vibrations as well as at deepening the understanding of underlying physical mechanisms. Being well equipped with both, a growing number of highly qualified academic staff members and modern, state of the art installations and utilities, the Institute soon belonged to the highly respected key institutions of its kind in Germany and Europe.
This development was essentially driven by acoustic requirements for fast reconstructions and later for growing comfort expectations which more and more turned acoustics to an important interdisciplinary field of modern science and technology. The paper reviews the driving forces of this development as well as the results of the Institute's work which was greatly influenced by its directors Lothar Cremer and Manfred Heckl.

Keywords: *History of Acoustics, Engineering Acoustics, Technical Acoustics, Lothar Cremer, Manfred Heckl.*

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1. INTRODUCTION

Based on its long tradition in both, groundbreaking research results (e.g. Hermann von Helmholtz) and pioneering industrial developments (e.g. Werner von Siemens), the vibrant city of Berlin provided - in the first half of 20th century - an inspiring, state-of-the-art environment for further developing and applying the discipline of Acoustics.
At that time, after the comprehensive works of Lord Rayleigh and Helmholtz, Acoustics was seen to be well understood, not needing more basic research. However, driven by the need to better understand all aspects of acoustics to improve the quality of newly introduced (1923) broadcasting, several national authorities combined their support to promote further targeted investigations in Berlin. Prominent protagonists of these were Erwin Meyer and Lothar Cremer who - by the success of their work - had formative influence on substantial and institutional alignment of acoustic research in Berlin. Since 1929, they maintained continuous research and teaching in the field of applied acoustics at the Institute of Mechanics at Berlin's "Technische Hochschule" (TH, Technical University). These activities were complemented and extended by the young Heinrich-Hertz-Institute (HHI) for Vibration Research, founded in 1929. Here, one of four departments (led by Erwin Meyer) was uniquely devoted to research in Technical Acoustics. Thus, although being subordinated to institutes of mechanics and vibration research, Acoustics was well established and supported as an autonomous discipline of acknowledged relevance.
After the disastrous destructions of World War II, new formation of the then so-called Technical University (TU) of Berlin led to the explicit foundation of an Institute of Technical Acoustics (ITA) which, together with the ongoing work of HHI, was devoted to cope with growing demands in the area of applied Technical Acoustics.

This paper reviews the foundation of ITA in 1954 and traces its successful, most influential work in the second half of 20th century, i.e. up to the year 2000. In doing so it widely follows the valuable collection of historical facts and materials compiled by Peter Költzsch in [1].

2. ACOUSTICS AROUND 1950

By the beginning of the 20th century, scientific understanding of physical acoustics was highly developed and fixed in advanced, comprehensive theories, Helmholtz' "On the Sensations of Tones" (1862) and Lord Rayleigh's "Theory of Sound" (1894/96) being the most prominent ones. A little later only, the compilation of "Methods of Mathematical Physics" (1924) by Courant and Hilbert then had provided a rigorous mathematical treatment of the underlying physical correlations.

In parallel to the scientific exploration of physical acoustics, the end of the 19th and the first decades of the 20th century saw a rapid development of electroacoustic technologies to transduce, register, transmit, reproduce and - finally - broadcast sound. Apart from improving the sound quality of recorded (disc and tape) and transmitted (via phone and radio) sounds, Sabine had laid the foundation for targeted design and layout of auditory rooms to best adapt them to speech and music.

In addition to providing and improving desired sounds, control of undesired sounds also had become an issue which had caused first systematic investigations of particular sound generating, sound transmitting and sound controlling mechanisms ([2]). Prominent examples were

- Berger's mass law (1910) and the
- derivation and experimental verification of the coincidence effect by Cremer and Eisenberg (1942/48).

Together with the development of versatile measurement devices and adjusted assessment units (like "dB" and "phon" in the 20s), Technical Acoustics had become a discipline ready to serve new technical possibilities (electroacoustics), quality-conscious hearing requirements (room acoustics) and sound reduction requirements (noise control): Technical Acoustics was to become Engineering Acoustics.

3. THE INSTITUTE OF TECHNICAL ACOUSTICS AT THE TECHNICAL UNIVERSITY OF BERLIN

3.1 Foundation

As mentioned earlier, the discipline of acoustics had been taught at TH Berlin since 1929, when Erwin Meyer had become Director of the acoustic department of HHI and lecturer (1929-1934) or professor (1934-1945) for Technical Acoustics at the Institute of Mechanics/Vibration Research of TH Berlin. With the resources of HHI, TH Berlin was the first German university providing a lab exclusively devoted to teach and research acoustics. Supported by Lothar Cremer, who worked with Erwin Meyer at HHI and TH and, from 1940 to 1945, also gave lectures on acoustics in the field of Mathematics and Mechanics at TH Berlin, the group obtained important research results and thus soon was able to establish its excellent reputation.

Both, TH Berlin and HHI could not escape dreadful appropriation by the National Socialist regime and the resulting discrimination and expulsion of Jewish and critical scientists and students. However, being bewared, all in all, of direct military research and development tasks, the pre-war and war years allowed mainly focusing on purely scientific problems. Among these, basic water-borne sound projects saved the staff members from being sent to the front. But by the end of the war, the buildings and labs of Acoustics lay in ruins.

After the new opening of TH as Technical University (TU) in 1946, it was obvious to take up, as soon as possible, the successful scientific tradition of acoustics in the thirties and forties. However, general confusion and great destruction of war made any coordinated resumption of activities very difficult. It thus took until 1954 that the University came to a clear decision by closing down its own Institute of Vibration Research and founding the new Institute of Technical Acoustics together with a professorship of the same name. By April 1, 1954, Lothar Cremer was appointed to serve as both, Professor for Technical Acoustics and Director of the Institute.

Meanwhile, HHI was able to overcome its previous separation into a western and an eastern part and to restart on Oct.1, 1955, its activities as a non-university research institution being supported by a sponsoring consortium. In spite of its organizational separation, the institutes of HHI were closely interlinked with the corresponding institutes of TH and headed - in personal union - by their respective directors. Thus, Lothar Cremer also became head of the HHI Department of Acoustics.

3.2 Institute Facilities and Resources

In spite of generously concluded appointment negotiations, the newly founded institutes had to suffer provisional offices and facilities, the more as all excellent equipment of HHI had been destroyed in the war. It took until the sixties that the institute was freed from the tight situation at Jebenstraße by moving to optimal new lab facilities at Einsteinufer - in direct proximity to the new HHI building which opened a

few years later only. Here, the institute could use all state-of-the-art test and measurement facilities, including large absorbing and reverberation chambers, basins for water-borne sound, building and flow acoustic test stands and large premises for flexible test installations to comply with later requirements. In addition, the institute was given a well-equipped mechanical workshop as well as up-to-date measurement and computational equipment together with appropriate workshops for its maintenance.

From the very beginning, the ITA staff consisted of three groups of scientific employees: research assistants directly funded by the university, research assistants supported from external funds and members of the scientific staff of HHI whose acoustic department, until 1974, was led in personal union by the ITA director. This academic staff was complemented by qualified colleagues to serve and operate all technical equipment and workshops and to provide technical drawings and secretarial support.

Other than the members of the above mentioned non-professorial academic staff, who typically were employed along a strict time limitation scheme only, the lack of time limitations allowed professorial staff members to plan and implement long-term targets and strategies. In its first 50 years, this orientation mainly was given by the directors of the institute, Lothar Cremer (1954-1972) and Manfred Heckl (1973-1995). But other professors and lecturers were able also to effectively influence teaching and research of the institute: Prof. Ernst Lübke teaching noise abatement from 1955 to 1967 already, Prof. Matthias Hubert teaching and researching on various fields of Technical Acoustics from 1958 to 1993, Prof. Jürgen Gruber focusing - together with and followed by Prof. Christian Maschke - on assessing noise effects with special emphasis on sleeping disturbances and - since 1991 - Prof. Michael Möser complementing and extending the institute's research area by the fields of theoretical acoustics and structural dynamics and active sound control.

In recognition of the dominant guidance and orientation given by the institute's directors, the following overview is structured into two sections covering the periods of Lothar Cremer and Manfred Heckl.

3.3 Period of Lothar Cremer (1954-1973)

3.3.1 Brief Life Story of Lothar Cremer

Lothar Cremer was born in Munich on August 16, 1905, 9 years before the outbreak of World War I at a time where Germany still was an empire. He was the youngest child of Max and Elisabeth Cremer. The Cremers were a family of scientists: Lothar's father Max was a professor of animal physiology, his brother Hubert later became a professor of mathematics and his sister Erika a professor of physical chemistry. Also, Lothar Cremer's son Michael pursued an academic career later.


Figure 1. ITA Directors Lothar Cremer (left, 1954-1973) and Manfred Heckl (right, 1974-1995).

In 1911, the Cremer family moved to Berlin where Lothar's father Max had been appointed to the city's university. After a temporary stay of his family (at the end of the war in 1918) in Bavarian Sielenbach, Lothar Cremer passed his high school graduation (Abitur) in 1923 in Berlin. He played viola, violin and piano and initially was undecided whether to start a career in music or engineering.

For that reason, he first worked at a training school of AEG, a large general electricity company. Only then he decided to take up studies in general mechanical engineering first and electrical engineering later at TH Berlin. He received his diploma in 1930. His diploma thesis "*Zur Theorie der Frequenzabhängigkeit eines Wechselstromkreises mit Gleichstromgerät und Trockengleichrichter" (*On the theory of frequency dependency of an AC circuit with a DC device and metal rectifier) was supervised by Franz H. Ollendorff at the Institute of Theoretical Electrical Engineering.

Lothar Cremer then was doctoral student at the AEG Research Institute where he worked with Carl Ramsauer, Director of AEG Research and honorary professor at TH Berlin. In 1933, a few weeks after Hitler's rise to power only, he received (with summa cum laude) his doctoral degree for his dissertation "*Experimentelle und theoretische Untersuchungen über die Abhängigkeit der Schallabsorption vom Einfallswinkel bei porösen Wänden" (*Experimental and theoretical studies on the dependence of sound absorption from the angle of incidence to porous surfaces) which was supervised by Carl Ramsauer and Erwin Meyer (TH and HHI).

Later in 1933, Lothar Cremer then worked on structure-borne sound problems at the HHI department of acoustics (headed by Erwin Meyer) and, from 1934, also at the Institute of Mechanics of TH Berlin (as senior engineer). There, on March 27, 1936, he qualified as professor by his post-doctoral thesis (Habilitationsschrift) "Neue Methoden der absoluten Messung der Schallschluckung bei schrägen Einfallswinkeln" (New methods for absolute measurements of sound absorption at non-orthogonal angles of incidence). Later, from 1940 to 1945, Lothar Cremer gave regular lectures at the Institute of Mechanics

Although following up a variety of topical issues (e.g. control problems for torpedo guidance systems), Cremer's work continuously focused on the phenomenon of trace matching between an incident wave and a bounding structure (the then so-called coincidence effect). In 1942, this work resulted in his pioneering paper "Theorie der Schalldämmung dünner Wände bei schrägem Einfall" (Theory of sound insulation of thin walls at oblique incidence) being published in the "Akustische Zeitschrift" (Acoustics Journal). Its content is still part of the basic knowledge of any building acoustics engineer today.

Lothar Cremer and his family were bombed out twice and suffered the loss of almost their entire household. So, towards the end of the war, his family once more ended up in Sielenbach, Bavaria, where he still was able to use facilities at Lake Starnberg to continue his consulting activities for German Navy on questions of underwater acoustics and structure-borne sound insulation.

Soon after the end of war, the British occupation force - initiated by Erwin Meyer - asked Lothar Cremer to put together his recent works on structure-borne sound in vehicles and buildings. The result was the monograph entitled "Propagation of Structure-Borne Sound" which provided the basics for his later book on "Structure-Borne Sound" (co-authored by Manfred Heckl).

In Munich, Lothar Cremer moved into the house of his parents and soon took up two activities in parallel: In 1946, the American occupation force granted him the authorisation and business license to run a consulting engineering office. In addition, he received a teaching position as lecturer (1949-1951) at both, the Technical and the General Ludwig Maximilian University (LMU) in Munich, where he later was appointed adjunct professor (1951-1953).

Although his lectures were ambitious, Lothar Cremer knew how to inspire those students who followed until the end. He was able to point out that in spite of its physics being well understood, acoustics still has left open many questions of theoretical and practical interest.

In one year, among his students he found Manfred Heckl, Helmut Müller and Matthias Hubert who all accompanied and continued his academic and consulting work for many decades. This cooperation was started by employing the school friends Manfred Heckl and Helmut Müller as student assistants in his private acoustic lab, the "Akustisches Laboratorium".

Apart from many smaller projects, the acoustical design of a new concert hall (Herkulessaal) to be built within the reconstructed Munich Residence was a major task for Lothar Cremer and his team. Based on thorough analysis and measurements, the hall finally provided well balanced acoustics for multiple use with high sound isolation for studio recordings. This was achieved by combining proven approaches like improved prediction of absorbing elements (seats and carpets) or innovative measures like the world-wide first application of freely suspended reflectors.

Although running a successful consultancy, the highly respected researcher Lothar Cremer could – in longer terms - not withstand a continuation of his equally successful academic career. It thus was a fortunate but also logical coincidence that the initiative of TU Berlin to establish a new institute and professorship for Technical Acoustics found and appointed Lothar Cremer to be the founding professor and director of this institute.

So, together with his future senior engineer Manfred Heckl, Lothar Cremer in 1954 moved to Berlin and started his fruitful activity at the ITA of TU Berlin and HHI. Helmut Müller was planned to follow him later after having completed and concluded all current orders and contracts. Helmut Müller's failure in doing so prevented him from joining Lothar Cremer and Manfred Heckl in Berlin. On the contrary, his ongoing and promising business in Munich finally caused him to successfully continue it in a newly founded company, todays's Müller-BBM AG (see [3] for more details). In contrast to him, Matthias Hubert later also became senior engineer and professor at ITA in Berlin.

To complete the life story of Lothar Cremer, it must be mentioned that he received two high-ranking awards. In 1970 he was elected a full member of the Göttingen Academy of Sciences and in 1989 he was honoured with the Gold Medal of the Acoustical Society of America, ASA.

In the years after his retirement, Lothar Cremer lived in Miesbach, Bavaria, where he died on Oct.16, 1990.

3.3.2 Activities, Achievements and Impact

Lothar Cremer definitely was one of the last great personalities who were able to overlook and understand the many details and partial aspects of present acoustics together with their intercorrelations. However, although being interested in almost all fields of Technical Acoustics, he put particular emphasis on Physical Acoustics, Musical Acoustics,

Architectural (room and building) Acoustics, Structure-Borne Sound and Acoustical Measurement Technology. This can be verified in retrospect by the multiplicity of research topics he and his colleagues addressed since his appointment in Berlin. It also can be verified by the spectrum of topics he was able to enrich with new fundamental findings and comprehensive review literature. For the purpose of this review, this may be illustrated by some exemplary examples only.

Lothar Cremer himself considered three achievements as his most important contributions to science:

- general significance of the in-phase wave train closure principle which states that a natural (eigen-)vibration (resonance) occurs if a propagating wave after reflection at all boundaries along its path returns to its starting point with the same phase.
- coincidence (trace matching) effect, stating full sound transmission for a thin lossless plate if the trace wavelength of an incident airborne wave and the bending wavelength of the plate match.
- derivation of orthogonality and reciprocity from the reciprocal energy theorem. As Manfred Heckl showed later, this general theorem allows the derivation of extended reciprocity relations which, on their part, can be used to define indirect measurement procedures for air- and structure-borne sound sources in linear mechanical systems.

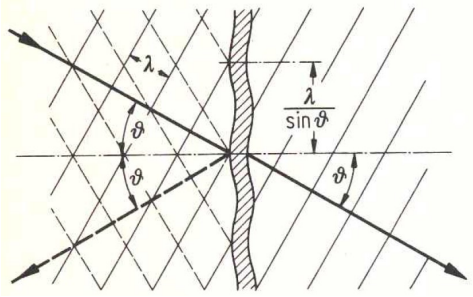

Figure 2. Original sketch to illustrate coincidence as match of airborne trace- and bending wavelength.

From a historical distance it can clearly be stated that the thematic scope of Cremer's most relevant contributions by far exceeds the three topics he mentioned himself. Instead of being listed in terms of particular findings and results, this may be illustrated here by a small but representative selection from his major publications:

- Lecture Notes on Technical Acoustics (co-authored by M. Hubert, continued by M. Möser)
  ambitious, didactically consequent introductory textbook to a broad spectrum of acoustic principles and applications
- Structure-Borne Sound (co-authored by M. Heckl, translated by Eric Ungar)
  prospective introduction and treatment of structural vibrations and sound radiation at audio frequencies,
- Principles and Applications of Room Acoustics in three volumes covering geometrical (1), statistical (2) and wave-theoretical (3) room acoustics
  comprehensive introduction, discussion and state-of-the-art conclusion of all aspects of room acoustics in both, theory and applicative practice,
- Physics of Violin (1981,1984)
  extensive monograph of the author's intensive research and scientific discussion on many physical phenomena and aspects of the violin and its playing.

Apart from this written heritage, one widely known example of Lothar Cremer's tangible heritage shall also be mentioned: the new Philharmonic Hall of Berlin, opened in 1963. This initially controversial (but style setting later) design of architect Hans Scharoun has developed to a reference as spatially inviting hall with arena-like orchestra setting amidst the audience. But it also owes its popularity to the inventive implementation of innovative room acoustic measures. In particular, the consequent introduction of stepped (vineyard) audience blocks improving direct sound supply and providing additional early reflection surfaces has essentially contributed to overcome the inherent difficulties with centered orchestra settings.

Figure 3. Berlin Philharmonic Hall.

Lothar Cremer has been a most influential researcher, initiator, supervisor and teacher who, by his own work as well as by the work of his assistants and research groups, has created and established an acoustic school – a school in picking

up contemporary technical challenges and, above all, in developing engineering methods and methodical approaches. Numerous student research and diploma theses, doctoral theses/dissertations and many comprehensive research and study reports summed up to outstanding progress in further developing technical acoustics and in applying it to engineering solutions - to engineering acoustics. Having laid important general foundations of engineering acoustics and having derived exemplary approaches and findings in architectural acoustics, it now was up to the next generation of the institute to address subsequent tasks in technical and engineering acoustics, among them the prominent challenge of industrial and transportation noise control.

3.4 Period of Manfred Heckl (1973-1995)

3.4.1 Brief Life Story of Manfred Heckl

Manfred Heckl was born on July 15, 1930, in Rennertshofen, Bavaria. His exceptional talents were obvious when he was a schoolboy yet and student later. He amazed by excellent work and by his phenomenal memory which surprised others many times again till the very end. During his studies of physics in Munich he came – together with his school friend Helmut Müller – across the very right teacher, the lecturer Lothar Cremer whose lecture on acoustics was able to fascinate and permanently bind the two friends to this discipline.

In 1954, Manfred Heckl completed his studies of physics with an experimental diploma thesis on sound bridges at floating floors. He then followed his teacher Lothar Cremer as scientific assistant to the just founded Institute of Technical Acoustics at the Technical University (TU) of Berlin. There, he graduated in 1957 with a PhD thesis on sound radiation and attenuation of cylindrical shells.

During his time at ITA in Berlin he also started his family. He married his wife Anna in 1956 and became a father of five children until 1964. His eldest daughter Maria followed his professional example and today does scientific research and teaching as Professor of Engineering Mathematics at Keele University in the UK.

After three years in the US, where he was with the reputable acoustic consultancy Bolt, Beranek and Newman, BBN, he returned to Germany in 1962 to start the German consultancy Müller-BBN in Munich together with his old friend Helmut Müller, his teacher Lothar Cremer, Ludwig Schreiber and the Engineering Consultancy BBN from the USA, represented by Leo Beranek.

Manfred Heckl has essentially contributed to shape this acoustical consultancy. His influence was formative in both, technical and economic matters. His profound understanding of physical and mathematical issues was the ideal basis for many novel approaches to solve the variety of new problems in practical engineering acoustics. His achievements and experiences were compiled in many technical reports. Among these he authored a comprehensive survey on generation and control of flow-induced noise which qualified him as post-doctoral lecturer ("Habilitation") in 1973. He thus best recommended himself to be reappointed for the chair of Lothar Cremer who had been given emeritus status in 1972.

To complete the life story of Manfred Heckl, it must be mentioned that he received two high-ranking awards. In 1992 he received the Rayleigh Medal of the British Institute of Acoustics (IOA) and in 1997 he was honoured posthumously with the Helmholtz Medal of the German Acoustical Society (DEGA).

Manfred Heckl had many plans for the time of his retirement where he wanted to return to Munich and to work with Müller-BBM again. But this was not to happen, he died on August 16, 1996 from the complications of a brain surgery.

3.4.2 Activities, Achievements and Impact

In the mid of 20th century when Manfred Heckl decided for his branches of acoustics, these acoustics were at the beginning of a period which more and more was to be characterized by problems of avoiding or reducing sound. Avoiding, controlling sound, however, can be done the better, the more its generation is understood. Consequently, all interest was directed to those phenomena which preceded the propagation of existing air-borne sounds: the generation of sound in gaseous and liquid media with and without flow and the excitation, propagation and radiation of structure-borne sound.

Manfred Heckl's profound knowledge of fluid and structural dynamics was the starting point for pioneering works. These works first thoroughly investigated the relation between the excitation of flat structures and the corresponding sound radiation and later then dealt with establishing and introducing statistical energy analysis, SEA. Other focusses of later research work were:

- description and numerical treatment of wave fields in coupled structures, inhomogeneous and layered media
- generalization and application of the reciprocity principle,
- investigation of complicated sound generating mechanisms, in particular for rolling noise on roads and rails,
- illustrative visualization of complex acoustical fields even in many, partly brilliant films

Apart from the development of important new methods, the greatest merit of Manfred Heckl may be seen in his exemplary application of theoretical insight to the numerous problems of acoustics in practice. To get there, numerical approaches always have been an aid, a tool to him but never a method by itself. As aid, however, he intensively used numerics. For this purpose, he was equipped in the 60s already with the first private terminal installed in Germany giving on-line access to a mainframe computer in the US.

The Heckl-specific mixture of phenomenal physical intuition, application-oriented ability to think in abstract terms and perfect mastery of mathematical methods for computation and approximation allowed him - apart from exact solutions - to find many useful and practicable formulas for estimation and prediction of acoustical parameters and field quantities. He thus really had an absolute vocation not only for further developing the current state of knowledge but also to apply it to practical problems, to make it available to the daily work of acoustic engineers.

Both, his preference for formulating, evaluating and approximating theoretical approaches as well as his continuous reference to practical problems are ideally summarized in an aphorism which he often liked to quote:

There is nothing as practical as a correct theory.

This motto best characterizes his approach and is exemplarily implemented in the famous book, "Körperschall" (Structure-Borne Sound, 1967), written together with Lothar Cremer based on Cremer's earlier monograph. This book forms a perfect and exemplary symbiotic relationship between these physical basics and their technical applications. A few books only manage to be labelled as a "bible" - being indispensable for both, introduction and reference, over a long period of time, and successfully bridging the gap between the ways of thinking in acoustics and continuum mechanics/structural dynamics.

Other important and recognized books were and are the "Taschenbuch der Technischen Akustik" (1975,1994), edited together with Helmut Müller and written together with many German colleagues to compile all relevant information, knowledge and tools of the time and thus to successfully apply engineering acoustics to the many practical problems. A later, updated version has been edited in English as "Handbook of Engineering Acoustics" (2013).

Again, as for Lothar Cremer before, the far-reaching impact of the achievements of Manfred Heckl together with his many assistants and research groups go beyond the scope of this survey. Instead, some major achievements shall exemplarily demonstrate both, the methodological continuity as well as the topical adaptability of the Berlin school of Technical Acoustics:

- systematic investigation and description of air-, fluid- and structure-borne sound generating mechanisms;
- systematic investigation, classification and guidance to understand and control generation and transmission of structural vibrations and waves and their radiation as air-borne sound waves from vibrating structures; Apart from providing rules and tools for a variety of typical applications, the engineer-oriented consideration of structural and structure-borne phenomena and methods opened a completely new perspective to technical and engineering acoustics;
- systematic application of insight into structural dynamics and radiation to analyze typical building constructions and to predict the effect of control measures in building acoustics;
- basic investigations and triggering impulses for comprehensive research efforts and programs to understand and model the generation of rolling noise and vibrations; Seen from today, these activities were able to create crucial basics for a useful rolling noise generation model which successfully has been used later to identify influential rolling noise parameters and to predict their influence on controlling the rolling noise of both, road/tyre and wheel/rail interaction.

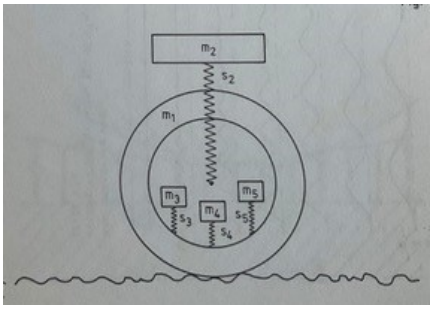

Figure 4. Early sketch of simplified parametric rolling noise generation model by M. Heckl.

When initiating and following up working topics, Manfred Heckl did not follow his personal interests only. Instead, he always tried to extend the working spectrum of his institute. As an example, he initiated early investigations on active control of vibrations and waves.

Apart from his research activities, Manfred Heckl's teaching activities have also left clear traces. His main lectures dealt with Theoretical Acoustics, Structure-Borne Sound, Flow Acoustics, Noise Abatement and Traffic Noise. With these lectures Manfred Heckl introduced a new formal tradition which was characterized by a clear and systematic theoretical basis. This included the concept of general

mechanics as well as a consequent treatment of advanced mathematical tools. The lectures also were characterized by high clarity and by many instructive experiments to illustrate the basics of acoustics.
All in all, Manfred Heckl continued and - in the sense of his time - completed transition to and establishment of engineering acoustics. Focusing on engineering architectural (building and room) acoustics in the immediate after-war years was consequently followed by focusing on the most relevant side effects of mechanization and industrialization: industrial and transportation noise. Having essentially contributed to identify and control flow-induced noise as an important source of industrial noise before he was appointed professor of Technical Acoustics in Berlin, he then initiated and pushed forward successful research work for effectively controlling rolling noise as major source of transportation noise. Thus, when Manfred Heckl was given emeritus status in 1995, his Institute of Technical Acoustics had essentially contributed that engineering acoustics was well developed and established to cope with the challenges of time.

3.5 Following Periods (after 1995) and Outlook

The early death of Manfred Heckl had left the institute with the task to maintain its competence and reputation while adapting its profile to changed needs and requirements. Acoustics had become an established engineering discipline, putting more emphasis on application-oriented research and development than on the self-related exploration of new approaches. Consequently, the number of acoustic institutions specially dedicated to other disciplines like architectural, civil, mechanical or automotive engineering had increased at the expense of previous institutes of cross-applicational competence.
However, the overlapping continuity provided by Michael Möser was able to preserve and transfer the proven spirit of the institute into the new century, where the institute managed to successfully complete the generation change with the new professors Björn Petersson, Enno Sarradj, Brigitte Schulte-Fortkamp and Andrè Fiebig and thus to cope with new demands.

4. SUMMARY AND CONCLUSIONS

In direct continuity to the tradition of technical/scientific acoustics in Berlin, the foundation of the Institute of Technical Acoustics at TU Berlin ideally met the challenges of its time: to provide new, urgently needed insight and approaches for integration of acoustic aspects into engineering processes. The Institute soon turned out to be best positioned for this. Its directors Lothar Cremer and Manfred Heckl both were able to set and inspire well-targeted perspectives and to win, motivate and guide excellent teams to follow them with great success.
By its outreach, by the wide range of results as well as by the qualification of its research assistants and graduated students, the Institute essentially contributed to establish engineering acoustics as a powerful, indispensable engineering discipline. Engineering Acoustics thus had become the driving force of the renaissance of acoustics after 1950.

5. ACKNOWLEDGMENTS

It hardly can be emphasized enough to what extent historic reviews like the one given here depend on the most valuable collection of materials edited by Peter Költzsch in his series of publications on the history of acoustics. The authors particularly appreciate and recommend the comprehensive information given in volume 10 of the series. ([1]).
They also would like to express their gratitude to many former colleagues for remembering and contributing details from their personal experience.
Finally, both authors highly appreciate the opportunity to express - by this review article - their admiration and gratitude for the work and guidance they received from the Institute of Technical Acoustics at TU Berlin and – in particular – from their outstanding personalities, Lothar Cremer and Manfred Heckl. They both impressively extended, embodied and shared the great fascination acoustics has for acousticians and the relevance it has for the comfort of life and the preservation of our environment.

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